Missing Data in Midpoint Space: An Intuitive Approach

Jon F. Claerbout
Jeff Thorson

Six hours before the printing deadline of the previous report a substantial improvement was made in the estimation of missing data off the ends of a seismic section. The method is intuitively based although it bears a lot of resemblance to some of the mathematically formalized approaches. The result is displayed in figure 2. Although the results may be the best yet obtained, they still don't seem good enough for practical application.

During the past six months I hoped to formalize the procedure and obtain better results. But neither was done. Now the intuitive basis of the algorithm will be reported.

Process Flow

Start with the data set, a synthetic zero offset section padded by zero traces. Transform to model space, i.e. the depth domain. This was done by a Stolt method. The transform is indicated by **F** in figure 1. Next compute a smooth gain control function which will tend to uniformize the amplitudes of the migrated data. This gain control function is saved for later use. The application of this gain function is depicted by **G** in the figure. Next, return to data space with $\mathbf{F}^{-1}$ We are planning to generate a modification to our original data set. This will be permissible only where we have missing data. Thus we now truncate. This is like multiplying by a mask containing zeros where original data is missing and ones where it is present. Previous papers have referred to it as **S** for Select or **M** for Missing data select. It is depicted by **M** in the figure.

Next we retrace our steps, first with **F** into model space and then we make use of the saved gain control function by applying it inversely as depicted by $\mathbf{G}^{-1}$ With $\mathbf{F}^{-1}$ we return to the earth's surface with the fond hope that since we previously applied **M** perhaps we won't need to do it again. However, since gain control does not fully commute with migration, and since migration and diffraction are not inverse in the evanescent region, we do find it necessary to again apply **M**. We subtract the result from the original data set. The whole process may now be repeated.

Experience with the Process

It was discovered that repetition of the algorithm did not achieve much more than the first iteration. To achieve farther improvement I experimented with the gain control function. Automatic gain control is defined by dividing a trace by its envelope. I found that raising the envelope to various powers (from about 1 to 1.5) gave qualitatively different results. Larger powers placed more stress on cleaning up the weaker semicircles. This suggested using a different power on each iteration. The final cover was produced in three iterations with the power being successively 1, 1.25, 1.5.

The Decline of the Process

Not previously mentioned was a tendency for positive feedback in some regions of dip space. This was attributed to failure of the Stolt migration to be an exact inverse to diffraction. Hence some dip filtering was done at various stages. Jeff Thorson tried the process, introducing a few dead traces in the middle of the data set. The quality of the results declined further, perhaps more than was expected.

In view of these experiences we felt we had attempted too much. We were neither on firm ground mathematically, nor did we have a process which seemed likely to be a success in the field environment. This project has been set aside awaiting success on analogous problems.

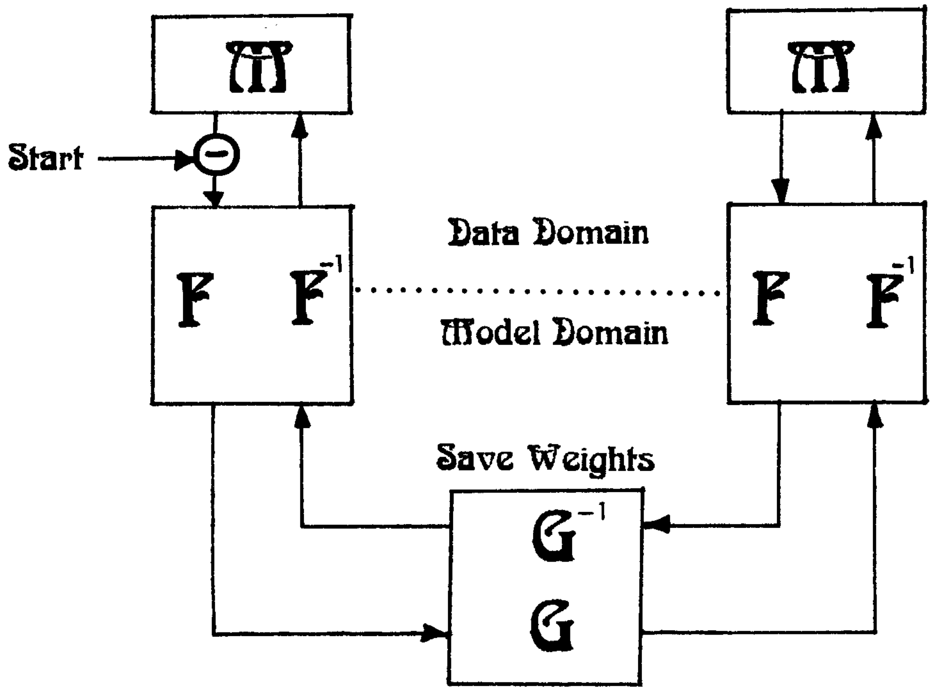

FIG. 1. Missing data extension procedure. **F** and F^{-1} are the constant-velocity migration and diffraction operators. **G** is an AGC operation. The weights are saved so that G^{-1} may be applied to the data coming back. **M** is the masking that selects the extended data (preserving the integrity of the starting data).

FIG.2. (next page) -- The result of applying the procedure to the three-beds model. The upper four panels are the original data plus the extended data in the time (data) domain for three iterations, progressing from left to right. The panels underneath are the corresponding data in the migrated domain (model domain).